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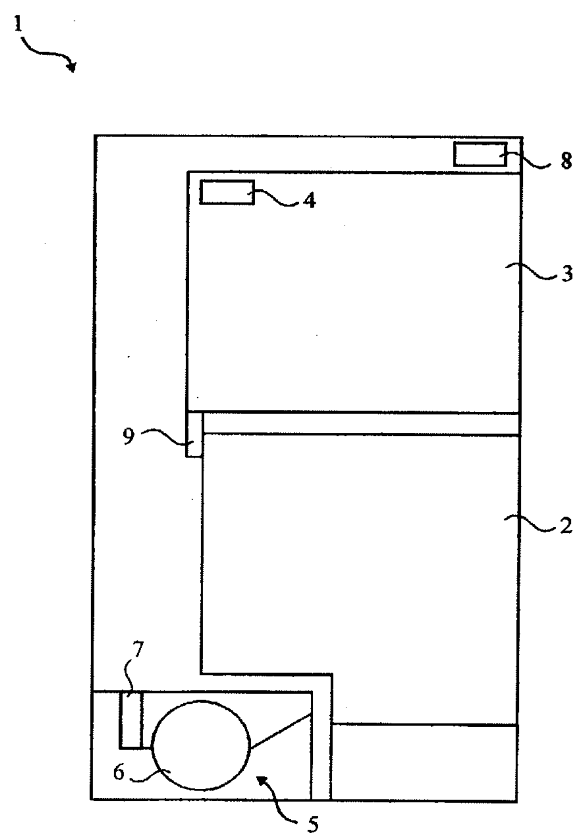

(57) Abstract: A refrigerator control method for a refrigerator (1) comprising a fresh food storage compartment (2), a freezer compartment (3), a temperature sensor (4) provided in the freezer compartment (3), a baffle (9) to control the flow of air from the freezer compartment (3) to the fresh food compartment (2), a compressor (5) compressing and circulating the refrigerant, provided with a motor (6), a convertor (7) enabling the operation of the compressor (5) at different numbers of revolution of the motor (6) and a control card (8) enabling said refrigerator to operate as required, which increases the capacity of the compressor (5) by increasing the number of revolutions for the motor (6) depending on the open/closed position of the baffle (9) and on the amount of the temperature increase in the freezer compartment (3) during the operation of said compressor (5), or decreases the capacity of the compressor (5) by decreasing the number of revolutions of the motor (6) depending on the freezer compartment (3) cooling speed when the baffle (9) is open.

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Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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REFRIGERATOR CONTROL METHOD

The present invention relates to a control method used in refrigerators that makes it possible to regulate the capacity of a compressor with variable capacity control.

In the state of art, compressors with variable capacity control which are briefly referred to as "VCC compressor" are used in the refrigerators. In such type of compressors, the control of capacity is possible. Therefore, the design of the refrigerator and its functions can be made by taking into consideration the general customer usage conditions which are close to the standard energy consumption. As it is possible to adapt the capacity of the compressor according to the conditions to which the refrigerator is exposed during its operation, this situation directly effects the energy consumption of the refrigerator in the positive sense. Various methods have been developed to control the capacity of the compressor.

One of said methods is disclosed in the US Patent No. 5586444, wherein the capacity of a VCC compressor is controlled by the PID method. However this method is sensitive towards the tolerances of the components on the cooling and air distribution system of the refrigerator. The PID parameters determined on one sample, may not give satisfactory results on another sample.

In another known embodiment of the state of art, the capacity of the compressor is adjusted manually. In this case the refrigerator can attain a low energy consumption but its cooling performance decreases as it cannot respond dynamically to the thermal loads occurring during operation.

In the European Patent Application No. 0859208, a control method is employed on a refrigerator with an evaporator that is connected in series to both of its compartments. In this method, the control for opening/closing the compressor is made by a sensor placed in the cooling compartment and the control of the compressor capacity is made by a sensor placed in the freezer compartment of the

refrigerator. This method is quite complex and cannot meet the requirements satisfactorily.

The object of the present invention is to provide the operation of the compressor at the optimum capacity according to the thermal and moisture loads occurring in the refrigerator.

The refrigerator control method realized to attain said object of the present invention has been illustrated in the attached drawings, wherein:

Figure 1, is the schematic view of the refrigerator
Figure 2a, is the flow chart of the refrigerator control method wherein the compressor capacity is increased,
Figure 2b, is the flow chart of the refrigerator control method wherein the compressor capacity is decreased,

The components shown in the drawings have been numerated individually as shown below:

1. Refrigerator
2. Fresh food compartment
3. Freezer compartment
4. Temperature sensor
5. Compressor
6. Motor
7. Convertor
8. Control card
9. Baffle

The refrigerator (1) comprises a fresh food storage compartment (2), a freezer compartment (3), a temperature sensor (4) provided in the freezer compartment

(3), a baffle (9) to control the flow of air from the freezer compartment (3) to the fresh food compartment (2), a compressor (5) compressing and circulating the refrigerant, provided with a motor (6); and a control card (8). A convertor (7) is used to enable the motor (6) provided in the compressor (5) to operate at different rotational speeds in order to control said compressor (5). The convertor (7) regulates the number of revolutions of the motor (6) of the compressor (5) depending on the signals sent from the control card (8) which evaluates the data obtained from the temperature sensor (4) placed in the freezer compartment (3).

In the method according to the invention, the compressor (5) operates at various capacities and the motor (6) runs in a determined range of revolutions per minute, e.g. 1600 and 4500 rpm, during the operational cycle of the refrigerator. The capacity of the compressor (5) increases as the number of revolutions increases. The variations of revolution in the motor (6) depending on the defined stages, are effected by the temperature in the freezer compartment (3) and the position of the baffle (9). In other words, when a change in the capacity of the compressor (5) is intended to be made, the temperature in the freezer compartment (3) and the position of the baffle (9) are controlled and then the decision on whether the number of revolutions of the motor (5) is to be changed or not, is made.

When the refrigerator (1) is first initiated to operate, the compressor (5) starts to operate at a maximum number of revolutions of the motor: thus, the refrigerator (1) attains the desired temperature as soon as possible. After the first pause, the compressor (5) drops to the minimum number of revolutions of the motor. Similarly, the compressor (5) operating at maximum number of revolutions before and after defrosting, then drops to minimum number of revolutions.

The refrigerator (1) control method according to the invention comprises two sub-decision processes, namely increasing and decreasing the compressor (5) capacity according to varying thermal loads. Both decisions are made during the time period when the compressor (5) is operating.

The decision to increase the capacity of the compressor (5) is made according to the following sub-decision process. In this sub decision process, first the on/off condition of the compressor (5) is checked (100). If it is operating, i.e. "on", the temperature in the freezer compartment (3) is controlled to see if it drops below the upper limit value (Tfreezer-max) of the temperature range within the limits of which the freezer compartment (3) temperature (Tfreezer) should be (101a). In case the temperature value of the freezer compartment (3) does not fall below the upper limit value of said temperature range, in a determined time period (101b), the compressor (5) capacity and thus the number of revolutions for the motor (6) is preferably upgraded one step (102). In case the temperature value of the freezer compartment (3) falls below said upper limit value, the first and last temperature values in a given time period are measured by the temperature sensor (4) and the differential temperature (ΔT) is calculated by subtracting the first value from the last value (103). If this difference of temperature (ΔT) is positive, i.e. there is a tendency to an increase in temperature, the open/closed position of the baffle (9) is checked (104). If the baffle is open, cooling of the freezer compartment takes longer, since the cooled air that is obtained by passing the air over the evaporator is directed to the fresh food compartment. On the other side, the freezer compartment cools faster when the baffle is closed. If it is open the calculated temperature difference (ΔT) value is compared to the predetermined first temperature difference ($\Delta T1$) value (105). If the temperature difference value (ΔT) is greater than the first predetermined value ($\Delta T1$), a decision to increase the capacity of the compressor (5) is made (106) and the number of revolutions of the motor (6) is increased; otherwise, i.e. if ΔT is smaller than $\Delta T1$, the capacity is kept constant and the process returns to step (103) where new temperature values are measured and a new temperature difference is calculated. In the 104th step, if the baffle is closed it is assumed that the freezer compartment will be cooled more rapidly and the temperature difference value (ΔT) is compared to a second predetermined difference value ($\Delta T2$), (107). If the temperature difference value (ΔT) is greater than the second predetermined difference value

(ΔT2), a decision to increase the capacity of the compressor (5) is made (106) and the number of revolutions for the motor (6) is increased; otherwise, i.e. if ΔT is smaller than ΔT2, the capacity is kept constant and the process returns to step (103) where new temperature values are measured and a new temperature difference is calculated. During the operation of the method according to the invention, if no increase occurs in the compressor (5) capacity, after it starts to operate or after its capacity is increased at any moment within a determined time period, its capacity is increased at the end of the determined time period (106). As the fresh food compartment (2) temperature may continue to increase for a certain time, after the increase in the capacity of the compressor (5), a decision to increase the number of revolutions for the motor once more, should not be made according to the measurements taken in this period, a certain time should pass before making a decision.

The decision to decrease the capacity of the compressor (5) is made according to the following sub-decision process. In this sub decision process, first the on/off condition of the compressor (5) is checked (200). If it is operating, i.e. "on", the temperature in the freezer compartment (3) is controlled to see if it drops below the upper limit value (Tfreezer-max) of the temperature range within the limits of which the freezer compartment (3) temperature ($T_{freezer}$) should be (201). When the freezer compartment (3) temperature value falls below the upper limit value of said temperature range, if the temperature sensor (4) detects (202) an increase in the temperature at any moment (20) considering the possibility of a thermal load, the sub-decision process to increase the compressor (5) capacity is repeated to determine weather such an increase is required or not. As long as the temperature sensor (4) continues to record decrease in temperature, the sub-decision process are carried on to decrease the compressor (5) capacity. The position of the baffle (9) is checked after this step (203); if it is closed no change in the capacity of the compressor (5) is made (204), but if the baffle (9) is open, the speed of cooling (Vcooling) is calculated (205). If the baffle (9) closes before a predetermined threshold period (t) is passed, the cooling speed is found by

dividing the difference between the temperature values at the moments when the baffle (9) is closed and when the baffle (9) is opened to the time period when the baffle (9) remained open; and if it is not closed during the predetermined open state period (t), the cooling speed is found by dividing the difference between the temperature value determined at the end of the threshold period and the value at the moment when the baffle (9) is opened, to the threshold period (t). Then the compressor (5) capacity corresponding to the actual compressor (5) capacity and cooling speed (Vcooling) is found from the table showing the experimental data (206) and the compressor (5) is operated after being brought to this capacity (207).

CLAIMS

1. A refrigerator control method for a refrigerator (1) comprising a fresh food storage compartment (2), a freezer compartment (3), a temperature sensor (4) provided in the freezer compartment (3), a baffle (9) to control the flow of air from the freezer compartment (3) to the fresh food compartment (2), a compressor (5) compressing and circulating the refrigerant, provided with a motor (6), a convertor (7) enabling the operation of the compressor (5) at different number of revolutions of the motor (6) and a control card (8) enabling said refrigerator (1) to operate as required, which increases the capacity of the compressor (5) by increasing the number of revolutions of the motor (6) depending on the open/closed position of the baffle (9) and on the amount of the temperature increase in the freezer compartment (3) during the operation of said compressor (5), or decreases the capacity of the compressor (5) by decreasing the number of revelations for the motor (6) depending on the freezer compartment (3) cooling speed when the baffle (9) is open.

2. A refrigerator control method as defined in Claim 1, comprising the steps of:
   - checking whether the compressor (5) is operating or not (100),
   - if the compressor (5) is operating, checking whether the temperature in the freezer compartment (3) drops below the upper limit value of the temperature range within the limits of which the freezer compartment (3) temperature should be (101a),
   - in case the temperature value of the freezer compartment (3) does not fall below the upper limit value of said temperature range, in a determined time period (101b), increasing the compressor (5) capacity and thus the number of revolutions for the motor (6) (102),

- in case the temperature value of the freezer compartment (3) falls below said upper limit value, measuring the first and last temperature values in a given time period by the temperature sensor (4) and calculating the differential temperature (ΔT) between these values (103),
- if this difference of temperature (ΔT) is positive, checking the open/closed position of the baffle (9), (104),
- if it is open comparing the calculated temperature difference (ΔT) value to the predetermined first temperature difference ($\Delta T1$) value (105),
- if the temperature difference value (ΔT) is greater than the first predetermined value ($\Delta T1$), increasing the capacity of the compressor (5) by increasing the number of revolutions for the motor (6) (106),
- if ΔT is smaller than $\Delta T1$, keeping the compressor (5) capacity constant and returning to step (103) where new temperature values are measured and a new temperature difference is calculated,
- in the 104^{th} step, if the baffle is closed, comparing the calculated temperature difference (ΔT) value to a second predetermined difference value ($\Delta T2$) (107),
- if the temperature difference value (ΔT) is greater than the second predetermined difference value ($\Delta T2$), increasing the capacity of the compressor (5) by upgrading the number of revolutions for the motor (6) one step (106),
- if ΔT is smaller than the predetermined second difference value ($\Delta T2$), keeping the compressor capacity constant and returning to step (103) where new temperature values are measured and a new temperature difference is calculated.

3. A refrigerator control method as defined in Claims 1 and 2, comprising the step of increasing the capacity of the compressor (5) by upgrading the

number of revolutions of the motor (6) one step, (106), at the end of a determined time period, if no increase occurs in the compressor (5) capacity, after it starts to operate or after its capacity is increased at any moment .

4. A refrigerator control method as defined in Claim1, comprising the steps of:
   - checking whether the compressor (5) is operating or not (200),
   - if the compressor (5) is operating, checking whether the temperature in the freezer compartment (3) drops below the upper limit value of the temperature range within the limits of which the freezer compartment (3) temperature should be (201),
   - when the temperature value of the freezer compartment (3) falls below said upper limit value, determining the change of temperature in the freezer compartment (3), (202), and in case there is an increase, the sub-decision process to increase the compressor (5) capacity is repeated to determine weather such an increase is required or not,
   - in cases when the temperature sensor (4) detects a fall in the temperature, checking the position of the baffle (9),
   - if the baffle (9) is closed, keeping constant the number of revolutions of the compressor (5) motor (6) and making no changes in the compressor (5) capacity (204)
   - if the baffle (9) is open and if the baffle (9) closes before a predetermined threshold period (t) is passed or if it is not closed during a predetermined threshold period, calculating the cooling speed (Vcooling) (205),
   - finding the compressor (5) capacity corresponding to the cooling speed (Vcooling) (206) and decreasing the compressor (5) capacity by down grading the number of revolutions of the compressor (5) motor (6), (207).

5. A refrigerator control method as defined in Claim 4, wherein the cooling speed value, calculated by dividing the difference between the temperature values at the moments when the baffle (9) is closed and when the baffle (9) is opened to the time period when the baffle (9) remained open, is used in case the baffle (9) closes before a predetermined threshold period (t) is passed.

6. A refrigerator control method as defined in Claim 4, wherein the cooling speed value, calculated by dividing the difference between the temperature value determined at the end of the threshold period and the value at the moment when the baffle (9) is opened, to the threshold period (t), is used in case it is not closed during the predetermined threshold period (t).

Figure 1

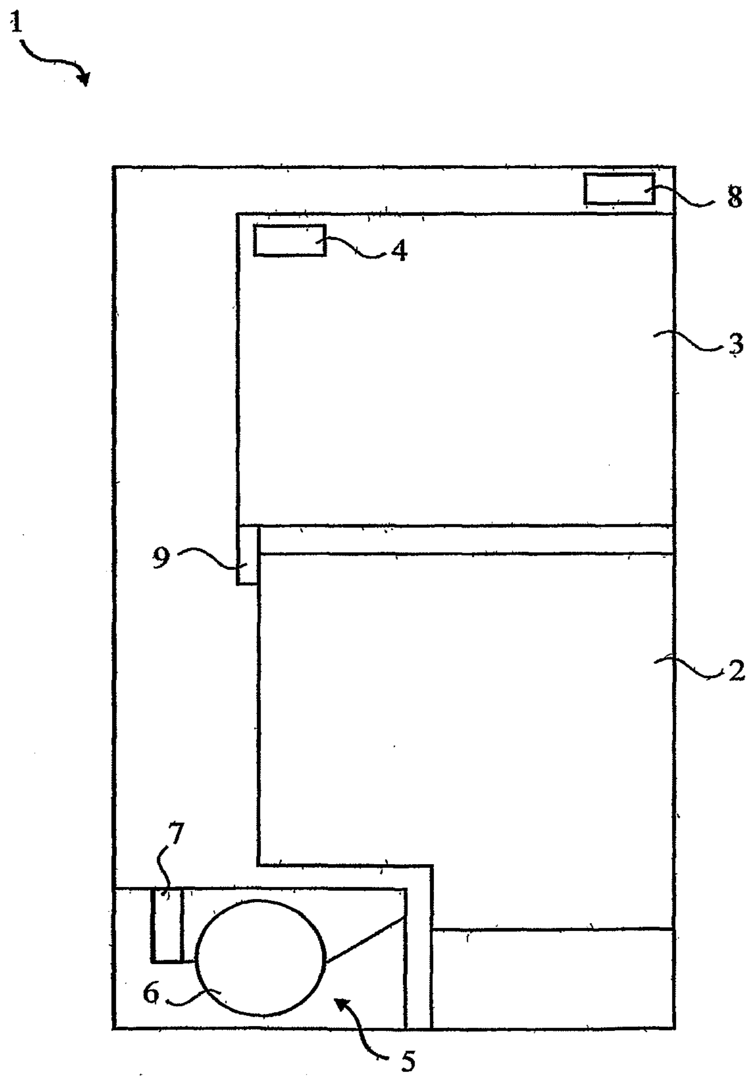


Figure 2a

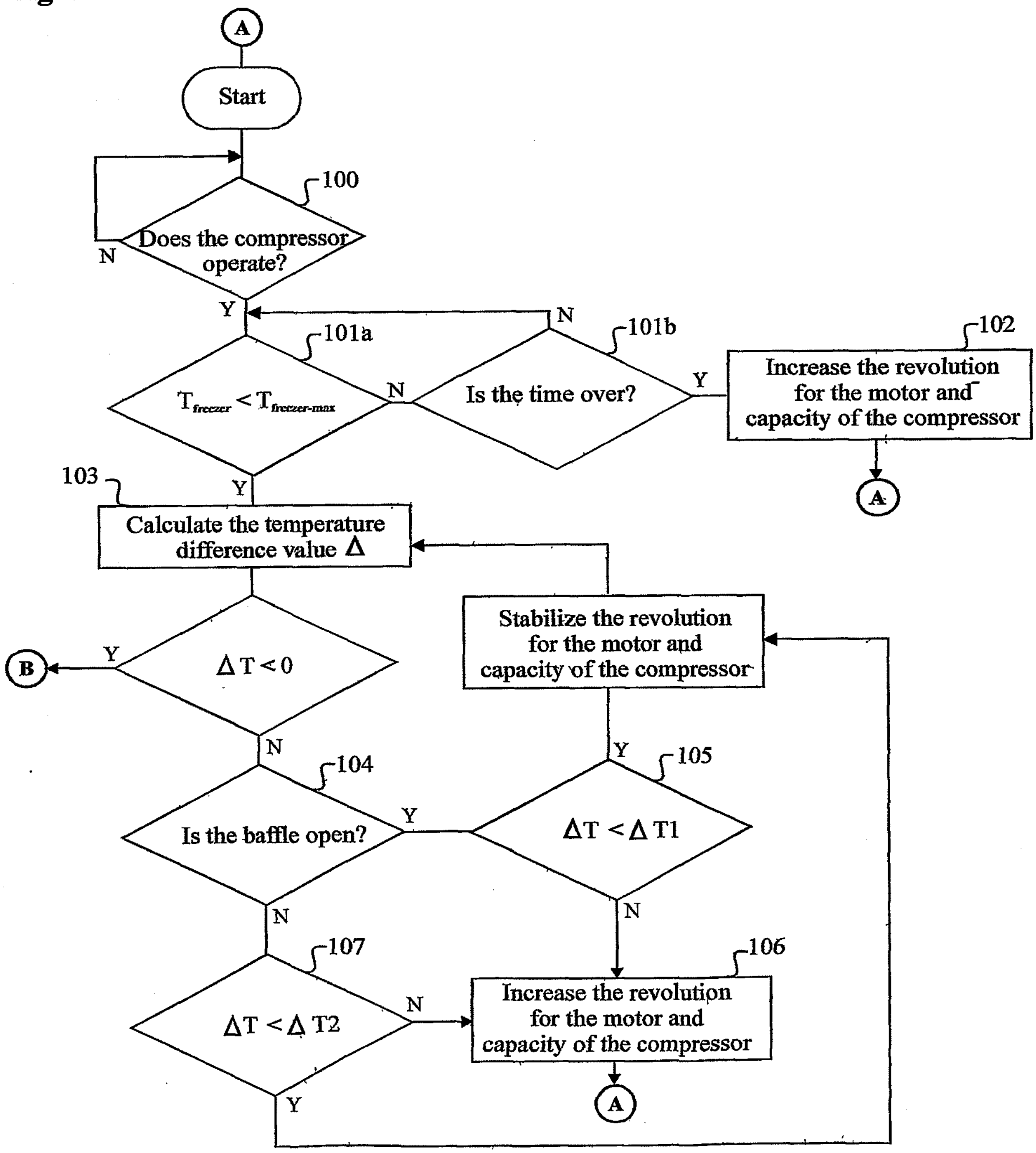
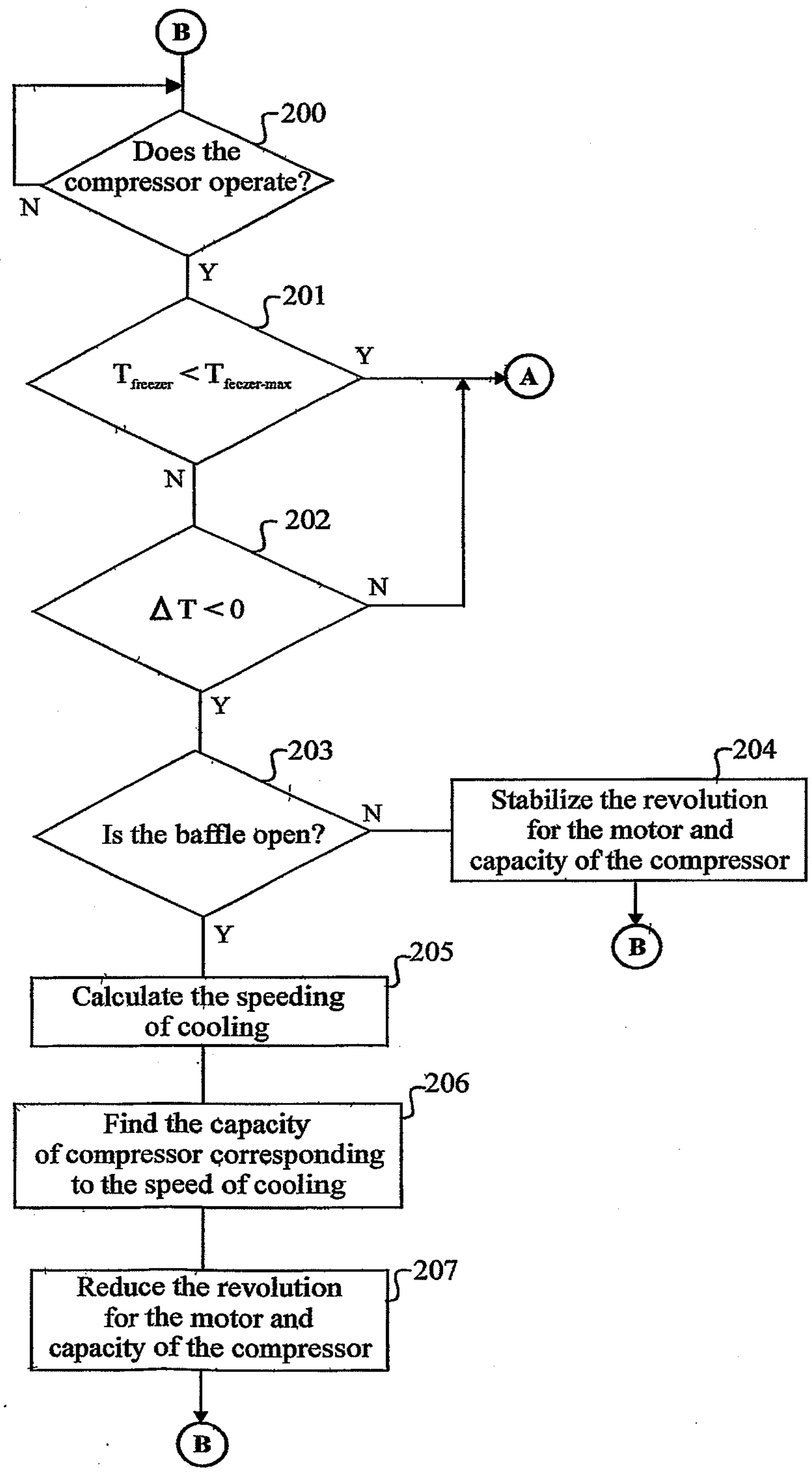

A
Start
100
Does the compressor operate?
N
Y
N
101a
101b
$T_{freezer} < T_{freezer\text{-}max}$
N
Is the time over?
Y
102
Increase the revolution for the motor and capacity of the compressor
A
103
Y
Calculate the temperature difference value Δ
Stabilize the revolution for the motor and capacity of the compressor
B
Y
ΔT < 0
N
104
Y
105
Is the baffle open?
Y
ΔT < Δ T1
N
N
107
106
ΔT < Δ T2
N
Increase the revolution for the motor and capacity of the compressor
A
Y

Figure 2b


B
200
Does the compressor operate?
N
Y
201
$T_{freezer} < T_{feezer\text{-}max}$
Y
A
N
202
$\Delta T < 0$
N
Y
203
Is the baffle open?
N
204
Stabilize the revolution for the motor and capacity of the compressor
B
Y
205
Calculate the speeding of cooling
206
Find the capacity of compressor corresponding to the speed of cooling
207
Reduce the revolution for the motor and capacity of the compressor
B

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F25D17/06 F25D29/00 F25B49/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F25D F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 555 736 A (WILLS FRANK E ET AL) 17 September 1996 (1996-09-17) column 5, line 1 -column 6, line 56; figure 2	1
A	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) & JP 07 019699 A (MATSUSHITA REFRIG CO LTD), 20 January 1995 (1995-01-20) abstract	1
A	US 5 255 530 A (JANKE DONALD E) 26 October 1993 (1993-10-26) column 3, line 54 -column 4, line 53; figure 2	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 December 2002	23/12/2002

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/TR 02/00056

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 711 159 A (WHIPPLE III WALTER) 27 January 1998 (1998-01-27) abstract; figure 1	1

INTERNATIONAL SEARCH REPORT
.... .rmation on patent family members

International Application No
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